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**APPLICATION
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TITLE: MOUNTING METHOD AND MOUNTING DEVICE

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MOUNTING METHOD AND MOUNTING DEVICE

Technical Field of the Invention

The present invention relates to a mounting method and a mounting device for bonding objects such as chips or substrates to each other, and specifically to a method and a device for forming a local chamber structure having a movable wall for locally enclosing a bonding part from surroundings and carrying out mounting.

Background Art of the Invention

Bonding objects to each other, for example, a mounting method for approaching a chip to a substrate at a condition of face down and bonding both objects to each other by pressing electrodes of the chip and the substrate to each other (as needed, accompanying with heating) is well known. Further, a method is also well known wherein, at the time of such a mounting, the mounting part is enclosed by surrounding it by a chamber, after the inside of the chamber is set at a specified atmosphere and various treatments are carried out, or after the pressure in the chamber is reduced and the inside of the chamber is set at a predetermined vacuum condition, the mounting is carried out.

However, when such a conventional chamber structure is employed, substantially the whole of the chamber, whose inner pressure is reduced, is formed as a rigid structure, the mounting is carried out in this chamber, and therefore, the structure is formed so that the whole of the mounting device or most of the mounting device is covered with the chamber. Therefore, the whole of the device including the chamber becomes a large-scale device, and there is a problem that the device becomes large and the cost thereof increases. Further, because the inside volume of the chamber also increases, it takes a long time to reduce the pressure down to a predetermined vacuum degree or to replace the atmosphere with a specified gas, and there is a case where it is

difficult to achieve a high vacuum-degree condition.

Disclosure of the Invention

Accordingly, an object of the present invention is to provide a mounting method and a mounting device which can realize a local chamber structure capable of locally and efficiently enclosing a bonding part and its vicinity from surroundings and adequately varying the shape of the enclosed space interlockingly with the bonding operation while maintaining the enclosed condition even at the time of bonding, and which can quickly and easily achieving a predetermined vacuum degree or specified-gas atmosphere by a small device using the local chamber structure, thereby easily and inexpensively satisfying various required treatment conditions or mounting conditions.

To accomplish the above object, a mounting method according to the present invention comprises the steps of positioning objects being bonded to each other, which face each other with a gap, relative to each other; moving a movable wall positioned around both objects until coming into contact with one object holding means to form a local chamber having a local enclosed space and enclosing both objects in the local chamber; reducing a pressure in the local chamber to set an inside of the local chamber at a predetermined vacuum condition; and moving the object holding means in a direction for reducing a volume of the local chamber and moving the movable wall following the movement of the object holding means and bonding both objects to each other by pressing.

In this mounting method, although the mounting step accompanying bonding operation can be started immediately after the above-described step for setting a predetermined vacuum condition, various treatment steps or a step for setting various conditions can also be interposed before starting the mounting step.

For example, in the above-described mounting method, a method can be employed wherein surfaces being bonded of the objects are cleaned in the local

chamber by an energy wave or energy particle beam after the pressure in the local chamber is reduced to set the inside of the local chamber at the predetermined vacuum condition, and thereafter, the object holding means and the movable wall following the object holding means are moved and both objects are bonded to each other by pressing.

In this case, the cleaning by the energy wave or energy particle beam can be carried out under the predetermined vacuum condition. Further, a method can also be employed wherein the cleaning by the energy wave or energy particle beam is carried out after reducing the pressure in the local chamber to set the inside of the local chamber at the predetermined vacuum condition, and after the cleaning and before the bonding, the inside atmosphere of the local chamber is replaced with an atmospheric inert or oxidizing gas. Although a plasma, an ion beam, an atomic beam, a radical beam or a laser can be used as the energy wave or energy particle beam, in particular, it is preferred to use a plasma from the viewpoint of its easy handling, device cost and simple structure.

Further, in the above-described mounting method, a method can also be employed wherein a sealing material is applied onto a surface of one object before or after the pressure in the local chamber is reduced to set the inside of the local chamber at the predetermined vacuum condition, and at the sealing material applied condition and under the predetermined vacuum condition, the object holding means and the movable wall following the object holding means are moved and bonding parts of both objects are bonded to each other in the sealing material by pressing. As the sealing material, for example, a non-conductive paste (both of a paste formation and a film formation are included) or an anisotropic conductive paste (both of a paste formation and a film formation are included) can be used.

Further, in the above-described mounting method, a method can also be employed wherein the inside of the local chamber is set at an atmosphere condition of a

specified gas after the pressure in the local chamber is reduced to set the inside of the local chamber at the predetermined vacuum condition, and under the specified gas atmosphere condition, the object holding means and the movable wall following the object holding means are moved and both objects are bonded to each other by pressing. In this case, the inside of the local chamber can also be set at the specified gas atmosphere condition with an atmospheric pressure. As the specified gas, an inert gas (for example, argon gas), a non-oxidizing gas (for example, nitrogen gas), a reducing gas (for example, hydrogen gas) or a substitutional gas (for example, a substitutional gas for a fluorine group) can be used. For example, in a case where heat bonding is carried out using solder bumps, a fluxless bonding under an environment replaced with a nitrogen gas becomes possible.

Further, in the above-described mounting method, it is possible to control the operational force of the movable wall at an adequate force in accordance with an operation at the present time. For example, in the step of setting the predetermined vacuum condition, by sealing the inside of the local chamber against outside by a contact force of the movable wall to the object holding means, the inside of the local chamber can be surely set at the predetermined vacuum condition.

Further, when the object holding means and the movable wall following the object holding means are moved, by substantially balancing a force acting to the object holding means by the pressure in the local chamber and a contact force of the movable wall to the object holding means, it becomes possible to suppress the force required for the movement of the object holding means and the movable wall following the object holding means to be small, thereby achieving a more smooth operation.

Furthermore, when the object holding means and the movable wall following the object holding means are moved and one object is pressed to the other object, the pressing can be performed utilizing the pressure in the local chamber by reducing a

contact force of the movable wall to the object holding means. For example, in a case where an upper-side object is held by a head having a cantilever structure, it becomes possible to prevent the application of a moment due to the pressing of the head side in the above-described method, and a high-accuracy mounting becomes possible. Therefore, it becomes possible to employ such a system.

A mounting device according to the present invention for bonding both objects to each other by pressing after positioning the objects relative to each other with a gap, comprises a movable wall positioned around the objects, capable of moving until coming into contact with one object holding means to form a local chamber having a local enclosed space capable of enclosing both objects in the local chamber, and capable of moving in a direction for reducing a volume of the local chamber following the movement of the object holding means; and a vacuum suction means for reducing a pressure in the local chamber to set an inside of the local chamber at a predetermined vacuum condition.

In this mounting device, the mounting device preferably has a cylinder means as means moving the movable wall. In such a structure, by controlling the supply pressures to the respective ports of the cylinder means, the movable wall can be easily moved and the operational force of the movable wall can be controlled easily at a high accuracy. It is preferred that a seal member capable of being elastically deformed is provided at a tip of the movable wall. It becomes possible to easily bring the tip portion of the movable wall into close contact with the object holding means by the seal member, thereby surely sealing the inside of the local chamber from surroundings. Moreover, also when adjustment of parallelism between a chip and a substrate or adjustment of alignment positions thereof is carried out, an amount required for the adjustment can be absorbed by this seal member.

Further, the mounting device may have means for cleaning surfaces being bonded

of the objects in the local chamber by an energy wave or energy particle beam.

Further, the mounting device may have a gas supply means for replacing the inside of the local chamber with an atmosphere of an inert gas or a non-oxidizing gas at the time of and/or after cleaning by the energy wave or energy particle beam.

The energy wave or energy particle beam is preferably a plasma, and when a plasma is used, each of the object holding means preferably has an electrode for generating a plasma. In such a structure, it is possible to easily carry out a desirable plasma cleaning in the local chamber.

Further, the mounting device can be constructed as a structure having means for applying a sealing material onto a surface of one object. As the sealing material, a non-conductive paste or an anisotropic conductive paste can be used.

Further, a structure can be employed for the mounting device, wherein the mounting device has a specified gas supply means for setting the inside of the local chamber at an atmosphere condition of a specified gas after the pressure in the local chamber is reduced to set the inside of the local chamber at the predetermined vacuum condition. As the specified gas, as aforementioned, any of an inert gas, a non-oxidizing gas, a reducing gas and a substitutional gas can be used.

Further, the mounting device can be constructed as a structure wherein at least one object holding means has a heating means. In a case where mounting accompanied with heating is required, this heating means can heat the bonding part.

Furthermore, in the mounting device, it is preferred that at least one object holding means has an electrostatic chucking means for holding the object electrostatically. Because the electrostatic chucking means can exhibit an electrostatic holding force in a vacuum condition, even when the inside pressure of the local chamber is reduced, the holding state of the object can be maintained with no problem. For this holding means, as shown in Fig. 1 described later, a three layer

electrode pattern for an electrostatic chuck, a plasma electrode and a heater may be provided.

In such mounting method and mounting device according to the present invention, since the local chamber structure is formed by using the movable wall, it becomes possible to locally and efficiently enclose only the portion of the objects facing each other, and to form a target vacuum condition easily and inexpensively without using a large chamber, therefore, without making the whole of the device large. Further, because this movable wall is moved following the movement of one object holding means and according to it the volume of the local chamber is properly decreased, both objects can be pressed while a target condition can be maintained, and whereby a desirable bonding is carried out. As a result, in spite of a small device, a reliable bonding state can be efficiently obtained, and a reliable mounting can be performed.

Brief explanation of the drawings

Fig. 1 is a vertical sectional view of a mounting device according to an embodiment of the present invention.

Fig. 2 is a process flow diagram of a mounting method according to a first example of the present invention, carried out by using the mounting device shown in Fig. 1.

Fig. 3 is a process flow diagram of a mounting method according to a second example of the present invention, carried out by using the mounting device shown in Fig. 1.

Fig. 4 is a process flow diagram of a mounting method according to a third example of the present invention, carried out by using the mounting device shown in Fig. 1.

Fig. 5 is a process flow diagram of a mounting method according to a fourth

example of the present invention, carried out by using the mounting device shown in Fig. 1.

The Best mode for carrying out the Invention

Hereinafter, desirable embodiments of the present invention will be explained referring to figures.

Fig. 1 shows a mounting device 1 according to an embodiment of the present invention. In Fig. 1, as objects facing each other with a gap, a case is exemplified where one object is a chip 2 and the other object is a substrate 3. A plurality of bumps 4 (in Fig. 1, two bumps 4 are shown) are provided on chip 2, and corresponding pads 5 (for example, electrodes) are provided on substrate 3. Chip 2 is held by a chip holding means 6 provided as one object holding means, and substrate 3 is held by a substrate holding means 7 provided as the other object holding means. In this embodiment, chip holding means 6 can be adjusted in position in Z direction (in a vertical direction), and substrate holding means 7 can be adjusted in position in X, Y directions (a horizontal direction) and/or in a rotational direction (θ direction).

Where, chip 2 means any object with any form being bonded to a substrate 3 regardless the kind and size, such as an IC chip, a semiconductor chip, an optoelectronic element, a surface mounting part and a wafer. Bump 4 means any kind of bump being bonded to pad 5 provided on substrate 3, such as a solder bump and a stud bump. Further, substrate 3 means any object with any form being bonded to chip 2 regardless the kind and size, such as a resin substrate, a glass substrate, a film substrate, a chip and a wafer. Pad 5 means any kind of pad being bonded to bump 4 provided on chip 2, such as an electrode accompanying with electric wires, a dummy electrode accompanying with no electric wire, etc.

Further, in this embodiment, the part of chip holding means 6 directly holding chip 2 and the part of substrate holding means 7 directly holding substrate 3 are

constructed as electrode tools 8 and 9 capable of functioning as electrodes for generating a plasma, respectively, and a heater is incorporated therein, the objects can be heated via at least one electrode tool, an electrostatic chucking means is incorporated therein, and at least one object can be held electrostatically. Although the heater and the electrostatic chucking means are not shown in the figure, known means can be used as both of them. In Fig. 1, label 10a shows an electrode terminal for an electrostatic chuck incorporated into the side of substrate holding means 7, label 11a shows a terminal for a plasma electrode, and label 12a shows a terminal for a heater, respectively, and electricity is supplied through an electrode connector 13. As the order pattern, it is preferred that an electrostatic chuck, a plasma electrode and a heater are disposed in order from the surface layer. Similarly, label 10b shows an electrode terminal for an electrostatic chuck incorporated into the side of chip holding means 6, label 11b shows a terminal for a plasma electrode, and label 12b shows a terminal for a heater, respectively.

Around both objects 2 and 3, provided is a movable wall 15 capable of moving until coming into contact with one object holding means (in this embodiment, chip holding means 6) to form a local chamber structure (a local chamber 14 is shown by the two-dot chain line in Fig. 1) having a local enclosed space for enclosing both objects in the local chamber, and capable of moving in a direction for reducing the volume of local chamber 14 (in this embodiment, a downward moving direction) following the movement of the object holding means (in this embodiment, chip holding means 6). This movable wall 15 is formed in a cylindrical rigid structure, and it can be moved vertically in Fig. 1 by a cylinder means 19 having a movable wall lifting port 16, a movable wall lowering port 17 and an inside sealing mechanism 18. A seal member 20 capable of being elastically deformed is provided at a tip of movable wall 15, and at the above-described contact condition, the inside of local chamber 14 can be sealed and

enclosed against the outside more surely.

In the side of substrate holding means 7, a vacuum pump 21 is connected to local chamber 14 thus constructed, as a vacuum suction means for reducing the pressure in local chamber 14 to set the inside of local chamber 14 at a predetermined vacuum condition. The air or gas in local chamber 14 is sucked by vacuum pump 21 through a suction passage 22. Further, separately from this suction passage 22 or together with this suction passage 22, a gas supply passage 23 for supplying a specified gas such as an argon gas (Ar gas) into local chamber 14 is provided in the side of substrate holding means 7.

Using mounting device 1 thus constructed, the mounting method according to the present invention can be carried out in the following various embodiments. Typical examples will be shown in Figs. 2 to 5.

First, in the mounting method according to a first example shown in Fig. 2, at the object setting step, chip 2 is held on the side of chip holding means 6 and substrate 3 is held on the side of substrate holding means 7. Next, at the alignment step, a recognition means 24 (for example, a recognition means having two sights of an upper sight and a lower sight) is inserted between both objects 2 and 3, the upper and lower recognition marks for positioning are read, and based on the read information, substrate holding means 7 is adjusted in X and Y directions, and further, as needed, in θ direction, to control the relative positional relationship between both objects 2 and 3 within a predetermined accuracy range.

After the alignment, a pressure for the lifting movement of movable wall 15 is supplied to cylinder means 19 through movable wall lifting port 16, and movable wall 15 is moved until the tip of movable wall 15 is brought into contact with the lower surface of chip holding means 6. By this, a local chamber 14 substantially enclosed from surroundings is formed, and both objects 2 and 3 are enclosed in this local enclosed

space. By sucking by vacuum pump 21 through suction passage 22 at the condition formed with local chamber 14, the pressure in local chamber 14 is reduced (vacuum sucked), and the inside of local chamber 14 is set at a predetermined vacuum condition. As the predetermined vacuum condition, for example, a vacuum degree of 130×10^{-1} Pa or less is employed. Because an electrostatic chuck is used for chip 2 or substrate 3, even if the condition is set at a high vacuum degree, the object holding state can be maintained with no problem. In a case where this vacuum degree in local chamber 14 is maintained after this step, by keeping the contact force of movable wall 15 to chip holding means 6 at a proper strength, the inside of local chamber 14 can be surely sealed from the outside and the inside can be maintained at the predetermined vacuum condition.

Next, the surfaces being bonded of the objects are cleaned by an energy wave or energy particle beam. Although this cleaning can be carried out even in the above-described high-vacuum state, because a plasma is used as the energy wave or energy particle beam in this example, in order to generate the plasma efficiently and easily, a required amount of Ar gas is supplied into local chamber 14 through gas supply passage 23 after the pressure in local chamber 14 is reduced to set the inside of local chamber 14 at the predetermined vacuum degree, and the inside atmosphere of local chamber 14 is replaced with Ar gas while the inside of local chamber 14 is maintained at the predetermined vacuum degree.

At this state, in local chamber 14, a plasma is generated between the upper and lower electrodes (electrode tools 8 and 9), and the surfaces being bonded are cleaned by removing organic substances and foreign materials on the surfaces of the objects by the generated plasma. By this cleaning, the surfaces being bonded are activated. In this plasma cleaning under the Ar gas atmosphere, the irradiation direction of the plasma can be switched alternately by switching the polarities of the upper and lower

electrodes alternately, and it becomes possible to efficiently clean both surfaces being bonded of chip 2 side and substrate 3 side.

Next, chip 2 and substrate 3, whose bonding surfaces have been activated by the above-described plasma cleaning, are bonded to each other. In the bonding step, although chip holding means 6 is moved down and following the movement movable wall 15 in contact with chip holding means 6 is also moved down, during this movement, because movable wall 15 is always maintained at a condition being brought into contact with the lower surface of chip holding means 6, the good enclosed state of the inside of local chamber 14 can be maintained as it is although the volume of local chamber 14 is reduced. At that time, if a force acting to chip holding means 6 by the pressure in local chamber 14 (vacuum pressure) (a force for moving chip holding means 6 down) and a contact force of movable wall 15 to chip holding means 6 are controlled at a constant relationship, the moving-down force of chip holding means 6 can be suppressed small, and the control of a pressing force for bonding due to chip holding means 6 after the contact of chip 2 with substrate 3 is facilitated.

Further, if a force acting to chip holding means 6 by the pressure in local chamber 14 (vacuum pressure) (a force for moving chip holding means 6 down) and a contact force of movable wall 15 to chip holding means 6 are substantially balanced, in a case where the head has a cantilever structure, a moment is not generated, it is advantageous on parallelism and positional accuracy. Where, "substantially balanced" means that there is no problem even if there is a slight difference between vertical forces, because the axis of vertical movement can be maintained. Further, even at the balanced state, because the contact force does not vary, the good sealing condition can be maintained as it is.

Bumps 4 of chip 2 and pads 5 of substrate 3 are brought into contact with each other and bonded to each other. Since both surfaces have been activated by the

aforementioned plasma cleaning and organic substances and oxides have been removed from the bonding surfaces, a room temperature bonding in vacuum condition becomes possible.

Fig. 3 shows a mounting method according to a second example. In this example, the process from the setting of the objects to the plasma cleaning under Ar gas atmosphere condition accompanied with switching of electrodes is substantially the same as that of the first example shown in Fig. 2. In this second example, after the plasma cleaning under Ar gas atmosphere condition and under the predetermined vacuum condition accompanied with switching of electrodes is performed, Ar gas is further supplied into local chamber 14 through gas supply passage 23, the inside of local chamber 14 is replaced with an atmospheric Ar gas (an atmospheric inert gas). Further, associated with that, the pressure of the movable wall lifting port is lowered down to a degree capable of maintaining the sealing.

Then, at the condition of the atmospheric Ar gas atmosphere, chip holding means 6 is moved down, following this movement movable wall 15 in contact with the chip holding means 6 is also moved down, and bumps 4 of chip 2 and pads 5 of substrate 3 are bonded to each other by pressing. Under the aforementioned vacuum condition, because a pressure is applied at a sealing portion of the movable wall, in a case where a slight inclination exists on the upper and lower holding means, there is a possibility that a moment generates and a positional shift in mounting at several-micron order may occur. However, if the atmosphere is returned to an atmospheric pressure condition and thereafter the mounting is carried out, such a moment is not generated, and a higher accuracy mounting can be performed. At that time, in this embodiment, the bonding is carried out further accompanying heating. The heating can be carried out by the aforementioned incorporated heater. In this bonding step, because the bonding surfaces of chip 2 and substrate 3 are activated by the plasma cleaning under Ar gas atmosphere

condition at the prior step, a desirable bonding can be performed by a relatively low-temperature heating. Namely, a required metal bonding between bumps 4 of chip 2 and pads 5 of substrate 3 can be achieved by a low-temperature heating.

Fig. 4 shows a mounting method according to a third example. In this example, at the step of setting the objects, or at the step of alignment, a sealing material 31 (in this example, a non-conductive paste (NCP)) is applied onto the surface being bonded of one object (in this example, substrate 3), and after the alignment, local chamber 14 is formed by lifting movable wall 14, and the inside thereof is vacuum sucked. At this step, first, air contained in the paste is deaerated. The inside of local chamber 14 is set at a predetermined vacuum condition, chip holding means 6 and movable wall 15 are moved down, and bumps 4 of chip 2 are pressed onto pads 5 of substrate 3. At that time, although sealing material 31 having been applied is expanded toward outside, because the sealing material 31 flows under the predetermined vacuum condition, residual air can be suppressed. Then, at the same time, or immediately after this step, bumps 4 of chip 2 and pads 5 of substrate 3 are bonded to each other accompanying heating, and at the same time, sealing material 31 is cured. If air remains at this time of curing sealing material 31, there is a fear that it remains at the form of voids by the increase of the volume due to the heating, but, because of a heat bonding under the predetermined vacuum condition, a voidless bonding becomes possible.

Fig. 5 shows a mounting method according to a fourth example. In this example, solder ball bumps 4a capable of being heat-melting bonded are provided as the bumps of chip 2. In this example, the process from the step of setting the objects to the step of vacuum suction is substantially the same as that of the first example shown in Fig. 2. In this fourth example, after the inside of local chamber 14 is set at a predetermined vacuum condition, the inside of local chamber 14 is replaced with an atmosphere of a specified gas. In this example, a non-oxidizing gas, especially, a

nitrogen gas (N_2 gas) with an atmospheric pressure is used as the specified gas. After the inside of local chamber 14 is replaced with the atmospheric nitrogen gas, chip holding means 6 and movable wall 15 are moved down, solder ball bumps 4a of chip 2 are pressed onto pads 5 of substrate 3, and they are heat bonded. Because of heat bonding in the nitrogen gas atmosphere, a secondary oxidation ascribed to heating can be suppressed, and at a fluxless condition, bumps 4a and pads 5 can be bonded at a high reliability.

As shown in Figs. 2 to 5, in the present invention, various conditions can be employed for the mounting formation. In any formation, local chamber 14 can be efficiently formed by the vertical movement of movable wall 15, and since movable wall 15 is vertically moved by cylinder means 19, it can be moved down following the movement of chip holding means 6 and a target atmosphere in local chamber 14 can be maintained even at the time of bonding operation, a reliable bonding state can be achieved.

Thus, in the mounting method and the mounting device according to the present invention, since a local chamber is efficiently and easily formed by a movable wall, and after the step for setting the inside of the local chamber at a predetermined vacuum condition, the object holding means and the movable wall are moved in a direction decreasing the volume of the local chamber while the inside of the local chamber is set at a target atmosphere and the state is maintained, and a desirable bonding can be performed, a reliable bonding state can be efficiently obtained by a small device.

Industrial Applications of the Invention

The mounting method and the mounting device according to the present invention can be applied to any mounting performed in a predetermined atmosphere, and in particular, they are suitable for a case requiring a small device or a case requiring to form a specified atmosphere condition for mounting with a small amount

of gas.